

The Edge of the Solar System Is Five Edges, and the Innermost and Outermost Differ by a Factor of 5106

— From the Kuiper Belt’s Outer Rim at **50 AU** to a Hill Radius of **255302 AU (1.237738 pc)** — And the Sun’s Gravitational Domain Reaches **95.07** Per Cent of the Way to the Nearest Star — [Paper 337]

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— *From thinking to syncing.* —

Abstract

A spacecraft is reported to have “left the solar system”. This paper asks which edge it left—the answer is that there are five edges, and it was the second from the inside. No new mathematical theorem and no new law is claimed. First, the five definitions run from **50 AU** to **255302 AU**, a factor of **5106.0345** (Section 2). Second, this is the core of the paper. The five are not a ranking; each names a different thing that ends (Section 3). Third, the outermost, the Hill radius, is computed here from the rotation of the Galaxy. It comes to **1.237738 pc**, inside the usual figure of about **1 pc** (Section 2). Fourth, the Sun’s gravitational domain reaches **95.07** per cent of the way to Proxima (Section 4). Fifth, light takes **16.8553** hours to the heliopause and **4.0370** years to the Hill radius (Section 4). Sixth, the separator is what it is that ends (Section 5).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the Hill radius, the heliopause, the Oort cloud, the Kuiper belt, and the galactic rotation curve are all standard. We do not build celestial mechanics—the three-body problem and the derivation of the Hill radius are not entered. The formula is used as given. We do not treat solar-wind physics—the termination shock, the structure of the heliosheath, and field winding are not entered. They are mentioned and no more. We do not adjudicate whether the Oort cloud exists—that it has never been observed directly is stated plainly. The figures are the accepted estimates. We do not treat interstellar space—the local interstellar cloud and the interstellar magnetic field are not entered. We do not treat mission operations—which craft measured what and when is not entered in detail. Relation to earlier papers: Paper 306 showed how many “base” units there are to be a promise—the five here are promises too, but none of them is arbitrary; each names where a different physical quantity ends. That there are several promises and that one of them is right are different matters. Paper 297 showed cosmic distance to be a ladder of seven rungs—there one quantity, distance, was measured seven ways; here one place, the edge, is set by five criteria. Many methods and many definitions are not the same thing. Paper 300 showed whether two things share a root is decidable—by that test the five here have distinct roots from one another. Paper 328 showed that the same ellipse being three months out was evidence of a different cause—there and here alike, two or more separate quantities ride on one astronomical object. What is added is putting the five in one table in one unit, computing the Hill radius from the galactic rotation curve and testing the tool on the Earth’s Hill radius, giving the jumps between neighbours to show the spacing is uneven, and putting the separator on what it is that ends.

1. Notation and the Question

Setting: The phrase “the edge of the solar system” is used in ordinary speech and in the press. But what counts as the edge has never been settled to one thing.

Observation 1.1

Voyager 1 was reported to have left the solar system in 2012. By another criterion the same craft has not left—not a contradiction; a different criterion.

Observation 1.2

The way of measuring is fixed first. All distances in astronomical units, with $1 \text{ AU} = 1.495978707 \times 10^{11} \text{ m}$ —ratios are invisible when the units differ.

Observation 1.3

Four of the five are accepted figures; one is computed here.The Hill radius alone is derived from galactic rotation——what is quoted and what is computed are written apart.

Question: How many edges are there, and how far apart do they lie?

2. The Five Edges in One Unit

Calculation 2.1: Compute the Hill radius from the galactic rotation curve (computed in this paper).Taking the Sun on a circular orbit at $R_0 = 8 \text{ kpc}$ with $v_c = 220 \text{ km/s}$, the enclosed mass is $M = v_c^2 R_0 / G$ and the Hill radius is $R_H = R_0 (M_\odot / 3M)^{1/3}$.

Quantity	Value
Enclosed mass $M(< 8\text{kpc})$	$9.0004 \times 10^{10} M_\odot$
Hill radius	1.237738 pc
the same	255301.7 AU
the same	4.0370 light years

Observation 2.2

Two checks.(a) The enclosed mass $9.0004 \times 10^{10} M_\odot$ falls in the usual decade of $10^{11} M_\odot$.(b) The same formula applied to the Earth gives $0.010003 \text{ AU} = 1496433 \text{ km}$, agreeing with the usual figure of about 1.5 million km——the tool is tried on another body whose answer is known.

Calculation 2.3: The five in one unit (all but the Hill radius are accepted figures).

Definition	Distance [AU]	What ends there
Outer rim of the Kuiper belt	50	the distribution of icy bodies
Heliopause	121.6	the solar wind loses to the interstellar medium
Oort cloud, inner edge	2000	the reservoir of long-period comets begins
Oort cloud, outer edge	100000	the same, outward
Hill radius (computed here)	255301.7	solar gravity loses to the Galaxy

Observation 2.4

Smallest to largest is a factor of 5106.0345. One phrase, “the edge of the solar system”——covering three and a half decades.

Calculation 2.5: The jumps between neighbours (computed in this paper).

Interval	Ratio
Kuiper rim → heliopause	2.4320
Heliopause → Oort inner edge	16.4474
Oort inner → outer edge	50.0000
Oort outer edge → Hill radius	2.5530

Observation 2.6

The jumps are uneven. The largest, 50.0000, and the smallest, 2.4320, differ by 20.5592——the five are not evenly spaced. The Oort cloud alone spans nearly two decades.

3. The Core: They Are Not a Ranking but Places Where Different Quantities End

Setting: Sort the five by what it is that ends.

Definition	What ends	Kind
Kuiper rim	the distribution of bodies	matter
Heliopause	the pressure of the solar wind	fluid
Oort cloud	the reservoir of comets	matter
Hill radius	the dominance of solar gravity	force

Observation 3.1

This is the core of the paper. The five do not differ in “how far one counts”——the physical quantity that ends is a different quantity in each case. A distribution of matter, a fluid pressure and a dominance of force cannot be converted into one another.

Observation 3.2

Apply the criterion of Paper 300.

Criterion	Result
Is there a correspondence preserving an identity	No. Pressure balance and gravitational balance are different equations
Does the same quantity appear	No. ρv^2 against GM/r^2
Do they keep agreeing as variables move	No. A stronger wind moves the heliopause alone

Observation 3.3

All three rows point to distinct roots. The heliopause moves year by year with the solar cycle; the Hill radius is set by the mass distribution of the Galaxy——move one and the other stays.

Observation 3.4

So “which is the real edge” is not a well-posed question. The question to ask is the edge of what—the position Paper 306 took on the count of base units, except that here there are five promises and not one of them is arbitrary.

Observation 3.5

The difference from Paper 297, stated. Paper 297 wrote that the distance ladder has seven rungs—there one and the same quantity, distance, was measured seven ways. Here the quantity being measured differs in all five. Many methods and many definitions are not the same thing.

Observation 3.6

To be stated honestly—the Oort cloud has never been observed directly. It is a structure inferred from the statistics of long-period comet orbits—two of the five (its edges) rest on weaker evidence than the other three. They are in the same table and are not equally certain.

4. How Long Light Takes

Calculation 4.1: Light travel time to each of the five (computed in this paper).

Definition	Distance [AU]	Light travel time
Kuiper rim	50	6.9306 hours
Heliopause	121.6	16.8553 hours
Oort inner edge	2000	277.2249 hours (11.6 days)
Oort outer edge	100000	1.5813 years
Hill radius	255301.7	4.0370 years

Observation 4.2

Light reaches the heliopause in under a day.16.8553 hours—a distance Voyager took 35 years to cover, light crosses while one sleeps.

Observation 4.3

To the Hill radius it takes 4.0370 years.Still inside the same “solar system”—in time, the factor of 5106 becomes something one can feel.

Calculation 4.4: Compare with the nearest star (computed in this paper).

Quantity	Value
Hill radius of the Sun	4.0370 light years
Distance to Proxima Centauri	4.2465 light years
Ratio	0.9507

Observation 4.5

The Sun’s gravitational domain reaches 95.07 per cent of the way to the nearest star.Which is to say there is almost no gap in interstellar space—the outside of this system and the outside of the next nearly touch.

Observation 4.6

To be stated honestly—the Hill radius is a domain against the galactic tide, not against the neighbouring star.The figure 0.9507 places two values from different criteria side by side—the gravitational boundary against a neighbouring star, an equipotential surface, is another calculation. It is not entered here.

5. The Separator: What Is It That Ends?

Observation 5.1

The separator——whether what ends at that boundary is a distribution of matter, a fluid pressure, or a dominance of force.

	What ends	Set by	Moves in time
Distribution	number density of bodies	formation history	no
Pressure	the solar wind	solar activity	yes
Force	gravitational dominance	the mass of the Galaxy	no

Observation 5.2

The last column splits the five in two.Only the heliopause moves year by year with the solar cycle——“the day it left the solar system” means something only at this boundary. The other four have no such day.

Observation 5.3

The separator can be moved.Stop the solar wind and the heliopause vanishes; change the mass of the Galaxy and only the Hill radius moves——the five can be moved independently, and so they are five independent things.

Observation 5.4

The press phrasing never says which edge.Saying “it left the solar system” leaves it unclear whether 121.6 AU or 255302 AU is meant——two figures a factor of 2099.5206 apart go under one phrase.

Observation 5.5

To be stated honestly——there is no need to settle on one “real” edge. What is needed is to say each time which edge is meant——as with the count of units in Paper 306, the promise is not the trouble; leaving the promise unstated is.

Observation 5.6

One last thing——only the outermost edge is not fixed by any property of the Sun. What sets the Hill radius is how hard the Galaxy pulls on the Sun——the outermost outline of the solar system was not drawn by the Sun; it was handed in from outside.

6. The Census and the Close

1. Five edges from 50 to 255301.7 AU (Calculation 2.3): a factor of 5106.0345.
2. Hill radius 1.237738 pc (Calculation 2.1): from galactic rotation.
3. Earth’s Hill radius 1496433 km (Observation 2.2): same formula, agrees.
4. Jumps from 2.4320 to 50.0000 (Calculation 2.5): not evenly spaced.
5. A different quantity ends in each (Observation 3.1): distribution, pressure, force.
6. Distinct roots on all three criteria (Observation 3.2): not interconvertible.
7. 16.8553 hours to the heliopause (Calculation 4.1): under a day.
8. 4.0370 years to the Hill radius (Calculation 4.1): inside the same system.
9. 95.07 per cent of the way to Proxima (Calculation 4.4): almost no gap.
10. Only the heliopause moves (Observation 5.2): only it has a date.

Closing: One phrase, “the edge of the solar system”, names five different places——the outer rim of the Kuiper belt at 50 AU, the heliopause at 121.6 AU, the inner and outer edges of the Oort cloud at 2000 and 100000 AU, and the Hill radius computed here from galactic rotation at 255301.7 AU (1.237738 pc). Smallest to largest is a factor of 5106.0345, one phrase covering three and a half decades. And the five are not a ranking——the physical quantity that ends is different in each. The Kuiper rim ends a distribution of bodies, the heliopause a pressure, the Hill radius a dominance of gravity, and these cannot be converted into one another. All three criteria of Paper 300 point to distinct roots. So “which is the real edge” is not a well-posed question——the question is the edge of what. It is the position Paper 306 took on the count of base units, except that here there are five promises and not one of them is

arbitrary. In light travel time the difference becomes something one can feel—the heliopause is **16.8553** hours away, so a distance Voyager took **35** years to cover, light crosses while one sleeps. The Hill radius is **4.0370** years away—still inside the same system. And that Hill radius reaches **95.07** per cent of the way to the nearest star—Proxima Centauri lies at 4.2465 light years. There is almost no gap in interstellar space. Though the Hill radius is a domain against the galactic tide and not against the neighbouring star, so this ratio places two different criteria side by side. One thing separates them—whether what ends is a distribution of matter, a fluid pressure, or a dominance of force. Only the heliopause moves year by year with the solar cycle—“the day it left the solar system” means something at that boundary alone; the other four have no such day. When the press says “it left the solar system”, 121.6 AU and 255302 AU, a factor of 2099.5206 apart, go under one phrase. To be said honestly—the Oort cloud has never been observed directly. It is inferred from the statistics of long-period comet orbits, and two of the five rest on weaker evidence than the other three. Nor is there any need to settle on one “real” edge. What is needed is to say each time which edge is meant. One last thing—only the outermost edge is not fixed by any property of the Sun. What sets the Hill radius is how hard the Galaxy pulls on the Sun. The outermost outline of the solar system was not drawn by the Sun; it was handed in from outside.

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